Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/834
CZECHOSLOVAKIA
February 1964
Submitted in:
ENGLISH and RUSSIAN

Confidential until official release during Conference

Abstract

STRENGTH PROBLEMS OF THE FLANGED JOINT

J. Kuchta

The successful solution of the removable joint of the cover with the bulk is one of the main problems in many nuclear power reactors. The importance of the reliable design of this joint rises with enlarging the diameter of the vessel.

The task arises in this connection to apply some of the classical flanged joint types or its modification to an extremely large and troublesome vessel. Various classical flanged joint types of course have not the same prospect to application in enlarging the vessel.

Therefore it is necessary in the first place to select the suitable type of the joint (type optimization) and further to select detailed dimensions (shape optimization). In this way it is possible to find technologically feasible shapes for the most challenging working régime, to eliminate undesirable bending stresses and to let the membrane stresses only.

As the model realization of both these optimizations is not economic, either timely or financially, one must optimize in the analytical way using an automatic computer. The designer gets satisfactory data for designing the joint in several hours. To check this design it is sufficient to gauge one chosen variant only.

Three types of the flanged joint were analysed for a vessel of 6000 mm diameter, about 70 at gauge pressure, with temperature differences in the joint in the order of several tens degrees centigrade, with pressing seal force equalling approximately 50% of the force acting on the cover and with further given technological and material conditions.

The joint with free flanges proved optimal and for this type the procedure of shape optimization is mentioned. To carry it out successfully and

fast it is necessary to gain curves of characteristic dependences of the stress in important cross-sections upon particular dimension changes.

The basis is the general strength analysis of a joint with free flanges carried out in the method of forces and processed into a program for an automatic computer. After designing the base dimensional variant approximately in the range of parameters of the vessel for which the joint is optimized, the system of dimensional variations is carried out. The influence of these dimensional changes upon the stress in important cross-sections of the joint is introduced in graphs. According to the character of the curves one may draw conclusions not only about the possibilities of the base dimensional variant but about the whole junction behaviour as well.

By means of gained information it is possible to achieve optimal shapes in a wide range of the vessel parameters with minimal number of further variants.

The paper is completed with graphs of characteristic curves for a joint with free flanges.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/835
CZECHOSLOVAKIA
February 1964
Submitted in:
FRENCH and RUSSIAN

Confidential until official release during Conference

Abstract

A SYSTEM FOR ACCURATE AUTOMATIC LOCATION OF FUEL ELEMENT CHARGING MACHINERY

J. Havel and M. Kondr

In the case described the charging machine makes it possible to change fuel elements whilst the reactor is operating at full load. In view of the need for protection against the high-intensity gamma radiation, it is of very heavy construction (250 tons, including the travelling crane).

The machine has to move over the reactor, over the fuel element cooling space, and over the spent and fresh fuel element store.

The track of the travelling crane is approximately 60 m in length and the tolerances for the alignment of the axis of the machine are very fine, especially over the reactor. The total deviation from the axis of the fuel-element channel may not exceed $\pm$ 0.5 mm, so that errors in the positioning of the crane track may not exceed $\pm$ 0.35 mm.

To achieve this accuracy the rate of movement of the machine must be low, although a greater speed is called for when it has to move over long distances. In order to meet these two requirements, a speed of 10 m/min has been chosen for long distances and 15 mm/min for the final accurate positioning.

In order to simplify the entire element-changing process as much as possible, a system has been devised for the automatic positioning and accurate centring of the machine. The co-ordinates are selected by means of a system of selsyns, the signal from which controls the driving motor switches of the machine through stops and triggers. The motors bring the machine rapidly towards the selected channel. At a certain point close to the final position, the signal from the selsyns is automatically replaced by that from a photo-electric system which ensures slow, precise location of the machine on the axis of the selected channel.

The advantage of this system lies in the fact that the signal from the photo-electric system is derived from a reflecting marker located at the end of the channel.

Accurate centring is therefore guaranteed, even if the axis of the channel deviates from its proper co-ordinates under the effects of temperature or of fabrication or other deformations. The photo-electric transducers, which are very small, are incorporated in an optical system which makes it possible to check the accuracy of location by direct observation of the reflecting marker or by closed-circuit television.

The entire system requires a relatively small number of connections between the operating point and the machine, since handling is very simple whether carried out manually or automatically.

As the photo-electric system signal is derived from the narrow edges of the image of the reflecting marker, most of the marker surface is free for observation and continuous control of the operation.

The operator controls the machine from his post by means of the selsyns and closed-circuit television.

Tests on a model installation have confirmed the reliability of the system.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/836
SOUTH AFRICA
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

LABORATORY AND PILOT PLANT TESTS ON THE PRODUCTION OF AMMONIUM URANOUS FLUORIDE AS AN INTERMEDIATE IN REFINING OPERATIONS

by

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and

Mr. C.W. Muir and Mr. G. Peratides
Government Metallurgical Laboratory, Johannesburg.

Ammonium uranous fluoride (UF_4NH_4F) was precipitated from a solution containing uranyl nitrate ($UO_2(NO_3)_2$), ammonium fluoride (NH_4F) and formic acid (HCOOH) by the introduction of sulphur dioxide (SO_2). Laboratory tests showed that at elevated temperatures the rate of precipitation of the UF_4NH_4F was constant and largely dependent on the initial HCOOH concentration. The constant driving force during the reaction was attributed to the continuous regeneration of an active reducing agent and a reaction mechanism based on the generation in a formic acid-formaldehyde sulphoxylate system was proposed. The practical advantages of reducing reagent costs by re-using the regenerated reducing agent were demonstrated.

Pilot plant tests showed that it was possible to produce a product of nuclear grade purity after having overcome severe corrosion problems. It is considered that the present relatively high reagent cost of $0.84 per Kg.U could be reduced to $0.31 per Kg. U on a larger scale of operation.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/837
ARGENTINA
February 1964
Original: SPANISH

Confidential until official release during Conference

Abstract

FABRICATION OF FUEL ELEMENTS FOR RESEARCH REACTORS.

by Carlos Araoz, Carlos A. Martínez Vidal, Jorge Mazza, Rino Morando, Oscar Wortman.
Argentine Atomic Energy Commission.

The first part of the work shows the fabrication of a fuel element for an experimental reactor for production of radio-isotopes (RAEP). Its maximum power is 5 MW, the neutron flux 2 x 10^{13} n/cm^2 sec., and it is cooled with ordinary water. The fuel element is of the MTR type. The core is made of an aluminium -15% uranium alloy. The uranium is 90% enriched. The cladding material is aluminium 1100. The well known method of "picture frame" was utilized to manufacture it.

The alloy for the core is obtained by a method developed in the Department of Metallurgy, Argentine Atomic Energy Commission. It consists of the direct reduction of uranium hexafluoride to an aluminium uranium alloy, 20 to 23 weight percent uranium. This alloy is remelted in an induction furnace, brought to composition and hot rolled at 580°C, to 3 mm thickness.

The core and frame for the picture frame is cut with the same die. The material is annealed, pickled, washed and dried. Then, the internal faces of the side sheets are wire brushed, as well as the core and frame. Finally, the assembly is sealed by an U-shaped indentation around the core, which will prevent the oxidation of the inner face by further heating as well as displacements between the side sheets and the core while rolling.

Translation provided by courtesy of the submitting Government

The whole set is hot rolled to 2.5 mm thickness, then cold rolled to 1.30 mm (final thickness of the element). A blister test is performed. The plates are flattened in a rolling straightener and then X-rayed to locate the core and verify dimensional tolerances.

Then, the plates are cut to their final size and identified. The element is transversally bent, and a chromatizing treatment is given as last finishing step. Finally they are placed in polyethylene bags.

The second part of the paper refers to the manufacturing process of a fuel element for the reloading of the RA-1 reactor. It is a cylindrical element, aluminium clad, sealed in both ends. The core is a rod 7,6 mm in diameter and its composition is 80% of 19.7% enriched UO_2 and 20% C, at least 50% of which is graphite. The U_{235} concentration is 0.50 $g/cm^3 \pm 0.01$ g/cm^3.

The working conditions are: maximum power 500 watts per element; maximum temperature of coolant 50°C; neutron flux 5×10^{11} n/cm^2 sec.

The core is made by hot extrusion of a powder mixture of the following composition: 70% UO_2 -14.5% graphite - 15.5% pitch.

The volatiles are eliminated by degassing in vacuum, heating slowly to 700°C. The ends are welded, leaving a hole in one of them with the following purposes:

a) avoid blow holes while welding,

b) eliminate adsorbed gases,

c) introduce He.

This hole is pressure sealed and manually welded. The thermal transfer is improved by hydrostatic pressing of the cladding at 150 kg/cm^2 and 350°C. The corrosion resistance is improved by a chromatizing process.

The third part of this paper briefly describes the manufacturing process of a cylindrical fuel element with a U_3O_8 - core and Al clad obtained by co-extrusion. From the extrusion results a sealed element with the following advantages: high efficiency, easy accountability of fissil material, simplicity and low cost of manufacturing.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/838
ARGENTINA
February 1964
Original: SPANISH

Confidential until official release during Conference

Abstract

RADIOMETRIC AERIAL AND EMANOMETRIC GROUND PROSPECTING METHODS IN ARGENTINA

Kirilo Marinkeff, Jorge Luis Gamba, Carlos T. Friz, Raimundo J. Jemma and Carlos G. Martínez

RADIOMETRIC AERIAL PROSPECTING

Sporadic aerial prospecting for radioactive ore deposits began in Argentina in the middle of 1958. Since 1960 the method has been applied systematically and, thanks to its greater economy and speed, has come to be used almost exclusively, in preference to ground prospecting, for the surveying of extensive uranium-bearing areas.

Up to the present 75 000 km^2 have been prospected, in various regions, and 550 radioactive anomalies have been discovered, 250 of which have been selected for surface examination. Fifty of these have already been investigated and found to contain uranium contents of varying amounts and, in many cases, of economic value.

The techniques and instruments used in Argentina are essentially similar to those current in other countries.

The authors describe the features of the instruments and the improvements made to them, and the methods used in the field operations, for interpretation and correction of records and for preparation of the final data, stating the methods of calculation used in all cases.

Mention is also made of a radiometric aerial prospecting trial over oil-bearing areas, covering 5000 km^2, in three separate regions of the country (Salta, Neuquén, Santa Cruz), and of the modifications made to the method for this purpose, aimed at eliminating, by means of geological interpretation supported by geochemical analysis, the errors due to the recording of radiation from thorium and potassium.

EMANOMETRIC GROUND PROSPECTING

Along with the application of the radiometric aerial prospecting technique, there has recently been a revival of the use of electrometers for the detailed prospecting of uranium deposits, because of the ease of application of the emanation method, the speed of field operations, and the larger volume of data obtained.

The National Atomic Energy Commission has carried out emanometric prospecting with Ambronn electrometers in various parts of Argentina.

The authors quote examples of use of the emanometric method to investigate the continuity of uranium mineralization, including the cases of the "Rodolfo" (Córdoba), "Los Adobes" (Chubut) and "Cuesta de Huaco" (San Juan) deposits, and to direct trial drillings and logging in areas where the mineralized strata lay under a thick alluvial cover. Subsequent exploratory work (drilling and mining) has confirmed the results obtained with this method.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/839
ARGENTINA
February 1964
Original: SPANISH

Confidential until official release during Conference

Abstract

NEW HYDROMETALLURGICAL TRENDS IN THE URANIUM INDUSTRY

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The uranium industry is at present going through a period in which reduction of costs must be regarded as one of principal objectives to be pursued.

Two methods of achieving this purpose are:

(a) refinement of existing techniques, with a view to deriving maximum yield therefrom;

(b) replacement of the present intermediate products by others offering better economic and technical prospects.

The Hydrometallurgical Groups of the National Atomic Energy Commission (NAEC) are carrying out a programme of tests involving application of both methods to the solid and liquid ion exchange technique, which is the one most commonly encountered in uranium technology.

For liquid ion exchangers, a comparative study has been carried out with a view to maximum utilization of their specific properties.

The first part of the paper contains a summary of the results of "preliminary tests" associated with any operation of this type, in order to facilitate the selection of the aminic solvent most suitable under the desired conditions.

With this purpose in view the paper offers a comparative study of the behaviour of certain amines with acid leachates, the results being expressed in the form of equilibrium curves, effect of pH, phase separation resolving power, effect of the diluent, and so on.

The results obtained show the undeniable advantages, under normal operating conditions, of certain tertiary amines over the others tested.

The second part of the paper, dealing with the search for new intermediate products, shows the results of studies on the potentialities of uranium carbonate compounds, particularly uranyl tricarbonate of ammonium (UTC) as a substitute for yellow cake.

UTC is highly versatile from the chemical and technological points of view, and its preparation is studied in connection with the technology of both solid and liquid ion exchange substances.

For each case a study is made of the conditions of preparation, the elimination of interfering factors, operating conditions and so on.

For solid ion exchange substances, the paper gives the results obtained with the delayed spontaneous crystallization technique, while for liquid ion exchangers the results of direct precipitating elution are quoted.

The paper concludes by analysing the prospects for preparing other materials on the basis of UTC, and gives a summary analysis of their respective economic advantages.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/840
UNITED ARAB REPUBLIC
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

INVESTIGATIONS ON SITE SELECTION FOR THE FIRST U.A.R. NUCLEAR POWER STATION

M.A. El Guebeily, K.E.A. Effat, K.A. Mahmoud, M.F. El Fouly, A. Ayoub, M. Esmat Aly and M. Obeid

This report illustrates the main problems involved in the selection of a suitable site for the First U.A.R. Nuclear Power Station and outlines the principal investigations which were carried out for the comparative evaluation of the various sites. The anticipated power of the station is 100 to 200 MWe and it will be integrated into the general electric 220 kV network.

The main problems for siting of this station arise from the facts that: (a) being the first project of its kind in the U.A.R., safety aspects had to be particularly emphasized; and that (b) the reactor type, being not yet defined, the selected site should satisfy the main requirements for various types of power reactors.

Studies for site evaluation have been undertaken by the U.A.R. Siting Committee over the last two years and the results of these studies have been presented for consultation to an IAEA Experts' Panel convened in Cairo in May 1963. Furthermore the Consulting Engineers Kennedy and Donkin, who have been appointed as consultants for this Nuclear Power Project, have carried out further studies on site selection since May 1963.

The site investigations included initially a preliminary general survey which led to the exclusion of certain regions due to obvious economic or safety reasons. These are Southern Egypt because of the cheap hydroelectric power from the High Dam Project, the Suez Canal area for safeguard of navigation, the big cities for the high population density and the Delta Region for safeguard of agriculture and population.

The site studies have therefore been concentrated on five areas, namely:

a) Inshas on the Ismailia Canal, about 40 kms N.E. of Cairo;

b) Burg El-Arab on the Mediterranean Coast, about 30 kms W. of Alexandria;

c) Wady Hof on the Nile River, about 20 kms S. of Cairo;

d) Fayoum on Lake Quarcon, about 80 kms S.W. of Cairo; and

e) El-Tahrir on one of the canals, near to and branching from the Rosetta Branch of the Nile River, about 60 kms N.W. of Cairo.

Detailed analysis and evaluation of these areas have been carried out from the viewpoint of the following aspects:

1 - Electrical requirements including electrical loads, distance from High Dam electric power, cost of connection to the 220 kV grid and cost supply of electric power during construction;

2 - Radiation safety requirements, including population density, meteorology, hydrology, fixation properties of soil and seismic phenomena; and

3 - Constructional and operational requirements including water availability, transportation facilities, civil construction considerations and availability of qualified and skilled personnel.

The various factors included in the above-mentioned aspects have been the subject of detailed technical reports presented by qualified experts representing specialized institutes in the country. The data included in these technical reports have been taken as the basis for the comparative evaluation of the different sites. In the light of these evaluations, three areas have been considered suitable for construction of a nuclear power station, namely: Burg El-Arab, Inshas and Fayoum. Certain differences exist however between them from safety and economic aspects. At the time of writing of this abstract, the final selection of the site of the First U.A.R. Nuclear Power Station is under consideration, taking into account the balance of the relative merits and drawbacks of the proposed three sites.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/841
UNITED ARAB REPUBLIC
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

BIOLOGICAL DISPOSITION OF ANTI-BILHARZIAL ANTIMONY DRUGS PART I. ESTIMATION OF ANTIMONY IN BODY FLUIDS BY ACTIVATION ANALYSIS

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A.R. Schulert, H.G. Browne and M.M. Mansour
(U.S. Naval Medical Research Unit No.3, Cairo, Egypt)

Neutron activation analysis is applied for the determination of antimony in body fluids. This method is used for following the disposition of anti-Bilharzial antimony drugs in biological samples. It consists of simultaneous irradiation of a standard and test sample in the Inshass 2MW Research Reactor (1.3×10^{13} $n/cm^2 sec.$), followed by dissolution and addition of Sb-carrier. In a single step, antimony is separated as the volatile hydride SbH_3, decomposed and dissolved in H_2SO_4 before counting. The chemical yield is determined spectrophotometrically. The procedure is used for routine analysis of various samples with good reproducibility, and gives adequate decontamination of antimony from foreign activities. Independently comparative assays were performed in some samples which were already tagged to a slight degree with antimony-124, and the methods were found to be consistent. Measurements under the conditions specified can assay levels of about 0.01 ppm antimony in biological ash of plasma and red blood cell samples of treated patients with an accuracy within $\pm 10\%$. The disposition of antimony drugs in man has been studied by the use of Sb-124 labelled material. Neutron activation analysis represents an alternative with the following advantages: (1) the method is 10-100 times more sensitive than the radioactive assay when the radiation dose to the patient is within acceptable limits, (2) the assay is accomplished with no radiation whatsoever to the patient, and (3) the necessity of specially prepared labelled material is avoided.

Results will be reported for biological fluids and excreted ova from patients. Data will also be presented on the disposition of antimonial compounds which were not readily available in labelled form.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/842
FINLAND
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

Generalized Potential Theory for Multigroup Diffusion in a General Multiregion Reactor

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This article contains the mathematical background for a new approach to the multigroup diffusion equations in general geometries, in many respects analogous to the classical potential theory. This approach has been referred to by the author in a previous paper.

The partial differential equations describing the static or kinetic behaviour of a multiregion reactor in diffusion approximation can be transformed into a system of linear integral equations for the surface fluxes and for the normal derivatives of the fluxes at the surfaces. If the interfaces include corners or concentrated source or other singularities, the role of the normal derivative will be played by an additive set function, from which arises a Radon-measure in the corresponding integral equations. The Green functions used are those for an infinite medium of the operators

$$A_i = \nabla^2 - \varkappa_i^2$$

in the static case, or,

$$A_i = \nabla^2 - \varkappa_i^2 - \frac{1}{c_i^2}\,\frac{\partial}{\partial t}$$

in the kinetic case. The singular Green functions and their derivatives normal to the surfaces appear as kernels in the equations.

In the light of potential theory every kinetic behaviour of a reactor can be interpreted as a result of either a change in the shape of the reactor regions (moving boundaries) or a variation with time of the boundary conditions at the stationary surfaces (time-dependent extrapolation length etc.). Hence even in the kinetic case the fluxes $\Phi_i(x,y,x,t)$ can be represented by means of generalized potentials of single and double layers distributed over surfaces in the (x,y,z,t)-space.

In both main cases the resulting set of integral equations can be written as a linear equation

$$x - Kx = f \qquad x,f \in E$$

for an element x of a certain Banach space E. The vector x contains components, which are several functions defined over the surfaces present in the reactor. K is a linear bounded transformation of the space onto itself. Even for the most general geometries there are standard methods for the numerical solution of the previous equation, but in some particularly simple cases analytical solutions can be found. This formulation is especially powerful in explaining some theoretical aspects of the solutions.

A short review is first given on the various types of boundary conditions of diffusion theory. Special attention is paid to the boundary layer representations connected with these conditions. Then the whole formalism used in this paper is established. Methods of numerical solution are discussed and some possible extensions of the theory presented. Finally the connection of this method with other approaches is considered, and its advantages and disadvantages are surveyed.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/843
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

Development of Rod and Hollow Type Swaged UO_2 Fuel Elements and Some Irradiation Behaviors

by Shuichiro Takahashi* Sc.D. Manager, Yutaka Honda*, Tadashi Kubota*, Shozo Fujinaga*, Chuko Ito** Director, Akio Takashima**, Yumi Akimoto** Sc.D., Takashi Suzuki**, and Hidekazu Doi**

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Fabrication processes of rod and hollow type swaged UO_2 fuel elements has been developed in connection with its irradiation behaviors.

As the feed, highly dense UO_2 powders were prepared by ADU-process. The precipitation of ADU under a particular condition was necessary, while for the firing in hydrogen of higher oxides (UO_3 and/or U_3O_8) relatively low temperatures of 1,200 - 1,750°C sufficed.

The means to realize the swaging effect including close-packing and particles-bonding are small reduction in area by each pass of swaging and much pass-number in given total reduction. A swaging machine designed to have successive sets of dies tandem was used in order to enlarge the swaging effect. For cold-swaged fuel rods, the maximum density was 93% of the theoretical. Straightness was better than 0.25 mm/m. Diametral variation was within ± 0.02 mm. The minimum thickness of the stainless steel sheaths of the rods swaged satisfactorily was 0.25 mm. Results of burst tests and autoclave tests on stainless steel sheaths and zircaloy-2

sheaths of swaged UO_2 fuel rods were not inferior to as-received sheaths before swaging.

Fabrication processes for hollow-type UO_2 fuel elements were to fill the annular space between the outer and inner tubes with UO_2 powder, to insert a mandrel into the hollow center, to swage the assembly, and finally to remove the mandrel. Hollow-type swaged fuel elements of 36 mm in outer diameter and 800 mm in length were fabricated without any defect in sheaths. Density of the UO_2 compact was 91 $\pm$ 0.5% of the theoretical. The maximum variation in thickness of annular layer of the UO_2 compact was within $\pm$ 0.1 mm.

An irradiation test of cold- and hot-swaged fuel rods was performed under the heat generation rate of 10 - 13 KW/ft and the burnup of 2,700 MWD/T-UO_2. The swaged fuel rods were highly resistive against thermal shock during the irradiation. The temperatures during the irradiation were 1,300 - 1,500°C at the center and 55°C at the surface. Sintering was recognized even in the UO_2 portion near the sheath, where temperature during the irradiation might not be enough to produce sintering phenomenon in the thought of normal sintering. The behavior of UO_2 fuel rods at high temperatures near or at the melting point was studied by a center line heating éxperiment at out-of-pile.

In an appendix, investigation of vibratory compaction technique using crushed UO_2 powder obtained from sintered pellets containing burnable poisons is described by Sumitomo Electric Industries, Ltd.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/844
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

URANIUM RESOURCES AND RECOVERY PROCESS IN JAPAN

Atomic Fuel Corporation

The result of the systematic prospecting by the Geological Survey of Japan and Atomic Fuel Corporation has shown that the national uranium ore reserve containing more than 0.01 % U_3O_8 is 3,000,000t (their average grade : 0.06 - 0.07 % ; total recoverable uranium content : about 2,000t).

At present, the ore reserve is concentrated at the Ningyo-toge district in the so-called Chugoku Massif region, South-West Japan. The uranium ore deposits occur horizontally in the basal parts of the Neogene Tertiary sedimentary rocks overlying granites.

In Japan, there are many areas with the similar geologic conditions to Ningyo-toge and in these areas, the energetic researches and prospecting are now under way, so that the sharp increase in the ore reserve can be expected in the future.

Juding only from their grade, it is impossible for Japan to compete successfully in the cost with accepted world price by the conventional production methods. In spite of their being low grade, the uranium ores in Japan have a lot of favourable properties, that is, they consist of very loosely cemented conglomerates and arkose, the uranium minerals occurring as fine grained crystalls in the soft and porous parts are easily soluble in acid, and there are almost no minerals interfering with processing or containing elements with high cross section for neutron absorption.

These characteristics enable us not only to expect the lowering of mining cost by hydraulic method, but also to develop the economical processing technology of domestic low grade ore.

The uranium recovery process developed by us is outlined below. The ore is crushed, washed and classified to ore concentrate of particles finer than 100 mesh. The grade of concentrate is of ca. 0.3 % U_3O_8 and the recovery amounts to 70 %.

Fine particles of ore are conditioned to about 20 % moisture, pugged uniformly with a small amount of conc. H_2SO_4, heated to 120°C for few minutes and then treated with hot water to leach uranium.

Thus we could improve the filterability very much because soluble colloidal silica is changed to insoluble form, and obtain a pregnant solution of higher uranium concentration than by conventional acid leaching.

The pregnant solution is treated by amine extraction process, and then uranyl sulfate complex is converted into chloro complex by scrubbing with conc. HCl, while being retained in the organic phase. The refined UO_2Cl_2 solution is obtained by stripping the solvent with very dilute HCl.

Finally anhydrous UF_4 is prepared through steps of electrolytical reduction, hydrofluorination and dehydration.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/845
JAPAN
February 1964
Submitted in: ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

SOME ASPECTS OF REACTOR ANALYSIS

Part I. Remarks on the Theoretical Treatment of a Homogeneous System
Jitsuya HIROTA[1] and Satoru KATSURAGI[1]

Part II. An Advancement on the Integral Transport Theory for the Heterogeneous System
Yuzo FUKAI[2], Ichiro KOMATSU[2], Hiroshi TAKAHASHI[1] and Takashi NAKAYAMA[1]

Part I. A series of critical experiments and theoretical analysis have been made on two-region systems in which a heavy water solution of uranylsulfate (^{235}U enrichment about 20 per cent) is surrounded by heavy water, poisoned with boron or mixed with thorium oxide.

In the analysis of these systems, leakage of fast neutrons from the core and competition of the leakage with resonance absorption in the core are important. To take these effects into consideration, it is required to adopt a multigroup model. For systems with a high fuel concentration, the spatial dependence of the spectrum becomes significant. The thermal flux distribution varies rather sensitively with the effective cross section adopted in calculation. Each region should be divided into many subregions with different effective cross sections.

The effective multiplication factor is reduced by the rigorous treatment of the fast neutron leakage from the core, and is increased by using space-dependent effective cross sections. Any disagreement in the effective multiplication factor found between the theoretical and experimental values might be attributed to uncertainties in the resonance integral of ^{235}U. These analyses suggest that the accepted value of $\nu I_f - L_a$ is about 50 b too large. The effective multiplication factors are also affected to some extent by the resonance integral of thorium.

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Part II. The integral neutron transport theory has been accorded more importance in calculations of heterogeneous reactors than the differential theory, for its applicability to more complex systems.

The effect of anisotropic scattering by the moderator atom on the flux ratio of the moderator to the fuel in the slab lattice is intensively studied, and the propriety of approximation by replacing the total cross section of the moderator by the transport cross section is investigated.

Exact expressions of first flight collision probability in the hexagonal and square lattices are derived in order to remove the error introduced by the cylindrical cell approximation. Although it has hitherto been believed to be difficult to obtain by the integral transport theory the collision probability in these lattices with anisotropic scattering, formulation of the probability is succeeded in the case of a cylindricalized lattice.

The factorization method in calculations of the thermal neutron spectrum is extended to the case of the integral transport equation, and the calculation method of fast fission effect without iteration is discussed in comparison with the Monte Carlo method.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/846
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

SUBCRITICALITY MEASUREMENTS BY PULSED METHOD AND CRITICAL EXPERIMENTS ON LIGHT WATER SYSTEM

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The present paper gives a brief outline firstly of the results of the pulsed experiments on graphite and light water moderated systems, and secondly of the critical experiments on H_2O - UO_2 system.

The experimental methods for reactivity measurement is a highly subcritical system, which are based on the measurement of persisting mode and based on that of prompt mode, have the theoretical and experimental difficulties. Those are stressed in a reflected system.

The purpose of the subcriticality study is to establish another concept to avoid the above-mentioned problems, and to describe rigorously situation of neutron multiplication in a reflected subcritical system. The concept is that the prompt neutron decay constant of fundamental mode α_o should be used directly as a measure of neutron multiplication. Because this quantity is to be uniquely measurable free from spatial and energetic dependence, and calculable from the fundamental equations. In order to prove this characteristic of α_o, a series of pulsed neutron experiments was made at various subcritical state in a reflected graphite moderated enriched fuel system (SHE) and a light water moderated natural UO_2 system, in JAERI and MAPI, respectively.

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The multigroup subcritical kinetics of the reflected reactor have been extended, and the direct comparison between the experimental results from pulsed neutron experiment and the calculated values from multigroup treatment about the above-mentioned systems have been made to investigate this concept. The difference between measured and calculated values of α_o was fairly small.

Reactivities, reactivity coefficients and flux distributions were measured with Ozenji Critical Facility, OCF (Hitachi, Ltd.) and Tanktype Critical Assembly, TCA (JAERI), and compared with theoretical analyses. Lattices studied with these facilities are of pelletized and swaged UO_2 cladded with Al tubes (enrichment: 2.5%, 1.5%, 1.84%: volume ratio: 1.5, 2.5 and 1.84).

Flux distributions for fully reflected and partly immersed cylindrical, rectangular and annular cores and thermal spectrum were measured with various activation detectors such as Dy, Cu, Lu, Au, Mn and In. Measurements of reactivity include those of critical mass, of temperature coefficient and of spatial dependent reactivity effects of void, fuel and absorption materials.

Results of these experiments were analysed primarily with a few group diffusion models and agreement between experiments and calculations was fairly good. More refined analyses taking account of the spatial dependent spectrum and transport approximations are now in progress.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/847
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

Theoretical Kinetic Studies of Boiling Water Reactors and Multiregion Reactors

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This paper consists of two parts. The first concerns a theoretical dynamic analysis of boiling water reactors, the second part is an analysis of multiregion reactor kinetics. The first part begins with the derivation of the equations describing the transient void formation in the core, then these equations are simplified and combined with other equations to form a complete mathematical model of the boiling water reactors. Finally, using the model, the reactor stability is investigated.

A simplified "void equation", describing the time-space dependent behavior of void volume fraction due to changes of reactor power, subcooling, inlet coolant velocity and system pressure, has been derived from the conservation laws of mass and energy, and numerical computations have been performed for transient void reactivity, using this void equation and the ordinary perturbation theory.

To supplement the validity of the void equation, the effect of momentum conservation is then considered. As a result two kinds of disturbances are identified, the usual void and the suppressed void by pressure wave. Although the velocity of pressure wave has been calculated to be very small in the steam-water mixture, it is considered to be still large enough for the high pressure transient. If the fast transient caused by a pressure transmission in the core is ignored, the equation resuces to the void equation previously discussed.

The void transfer functions are obtained by linearizing the void equation. Here uniform power distribution is assumed and the slip is ignored. Aside from these two simplifications, the resultant transfer functions are the most complete

distributed parameter model ever developed.

In addition to the void transfer functions, a complete set of other transfer functions is derived, namely, the inlet velocity transfer function, the vessel pressure tansfer function, the subcooling tansfer function and the recirculation flow transfer function.

The transfer functions derived above are further simplified and approximated by combinations of single time constant delays, whose time constants and static gains are readily evaluated from design parameters.

The dynamic characteristics of feedback transfer functions and the system stability are also investigated.

In the second part an analysis of multiregion reactor kinetics is undertaken, with the use of perturbation method and regional kinetics. In the perturbation method equations are introduced relating reactor period to perturbation conditions for multiregion reactor. These equations are applied for calculating the reactor periods associated with variation of thickness of reflector and for examining the inhour-equation. In regional kinetics one set of regional kinetics equations is derived by integrating the time dependent diffusion equation over each region of the reactor. These equations are expressed in explicit terms of physical parameters of each region. Based on these equations transfer functions and frequency characteristics of each region are examined.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/848
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

Kinetic Studies and Control of Nuclear Reactors by Statistical Methods

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The statistical analyses of nuclear reactors are given by both direct power spectrum measurement method and crosscorrelation method using binary noise. The experimental and analytical studies of reactor kinetics by those methods are summarized, with a special emphasis placed on noise spectrum of various reactors at critical and subcritical states by direct measurement and on the development of binary noise techniques.

Finally, the automatic start up of a research reactor by digital method is described.

The noise analysis of JRR-1 (water boiler type) was performed by band pass filter method at various power levels (0.5 W to 40 KW) and also by digital autocorrelation method at 40 KW. Combined with the results of pile oscillator method, Cohn's noise model is valid below 50 W, and at high power levels a couple of peaks appeared in low frequency region, one of which agreed with that obtained from Moore's model as well as Skinner-Hetrick's model. However, the other peak, which is not explained by Moore's model, seems to be caused by the void fluctuation due to radiolytic water decomposition.

Reactor power frequency spectrum measurements of HTR (swimming-pool type)

at various power levels (0.2 W to 100 KW) were made by band pass filter method with twin-T filters and speed-up techniques of tape recorder. At high power some of the resonance peaks were found in low frequency region. The absolute value of reactor power obtained by noise analysis based on Cohn's noise agreed below 5 KW with the indication of power meter.

A reactor noise analysis during shutdown transient has been proposed to determine negative reactivity of TTR-1 (swimming-pool type). In order to obtain high neutron flux level at subcritical state and to be free from the spatial effect of ordinary neutron sources, it was tried to obtain frequency spectrum of reactor noise by band pass filter method with a magnetic tape recorded while the power is decreasing by rod drop with a constant period associated with the longest delayed neutron decay constant. Experiments were made under several shutdown conditions. The observed break frequencies were equated to the theoretical formula, $\frac{\beta}{\ell}(1+\frac{\rho}{\beta})$, then negative reactivity was estimated from that equation with other parameters determined from a critical experiment.

The reactor transfer function measurements by the crosscorrelation function between reactor power and reactivity input has been carried out using reactivity variation in the form of several types of binary noise. First of all the random interval and the discrete interval binary noises are compared. From the bandwidth viewpoint, the latter is favorable. An error analysis, however, showed that pseudo-random binary noise of maximum period sequence is preferable to the real random ones. A custom-designed reactivity generator is driven by the binary noise recorded on magnetic tapes. The reactivity and the reactor power are recorded on magnetic tapes simultaneously. Both analog and digital techniques are used to compute the crosscorrelation function.

The automatic start-up of the TTR-1 from source level up to power level is made possible with a digital computer. A specially designed digital computer counts pulse signals from BF_3 counters every Δt seconds, and at the same time calculates reactor period for indication and for control. Reactor period is calculated by an approximate formula. The approximate value thus obtained provides a more stable estimate of period especially at lower count rates than with a conventional analog periodmeter. The control signal is so determined that the speed of the control rod is in proportion to an error signal of inverse period.
The digital start-up control system described is a part of a program for establishing completely computer-controlled research reactor system. It will also assure safe operation of reactors.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/849
JAPAN
February 1964
Submitted in: ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

HAZARD EVALUATION OF RADIOACTIVE CONTAMINATION OF SEA AND DECONTAMINATION OF RADIOACTIVITY IN FRESH WATER

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Part 2. Masamichi SAIKI, Hiroshi KAMADA, Taku KOYANAGI and Yasuo KUROSAWA
(National Institute of Radiological Sciences)

Part 1. Hazard Evaluation of Radioactive Contamination of Sea (by Y. Hiyama)

The author has been working on the experimental analysis of the quantitative relation in the levels of radioactive contamination between sea water and organisms since several years, three years of this period being sponsored by the IAEA, on the elements thought to be important in the waste disposal problem, such as Cs, Sr, I, Co, Zn, Cd, Fe, Ru, and Ce.

As a result of this series of numerous rearing experiments in the laboratory, it was possible to know the level of the concentration of a certain radionuclide in a certain tissue of an organism by knowing the concentration of it in the sea water and how long it has been in that environment.

The concentration factors, a ratio of the concentration of an element in a tissue of an organism to that of sea water, were obtained during the rearing experiments in tanks. The equilibrium value of the concentration factor differs greatly according to the systematical position of the organisms, and the rate of uptake differs according to the stage of growth of organisms and the temperature of the water.

The equilibrium values of the concentration factor obtained by this series of experiments were compared with those which were obtained by chemical analysis of the stable and radioactive elements by previous workers. There are some differences between the two results, and considerations were made on the reason of it.

Finally, a way to control and to monitor the radioactive contamination of the sea is described.

Part 2. Decontamination of Radioactivity in Fresh Water
(by M. Saiki et al.)

From the viewpoint of radiological safety, contamination of fresh water by radioactive effluents and fallout has become a serious problem in recent years. Since fresh water is a basic necessity of man, the studies in this paper are based on our experiments on the relationship of radioactivity among water sources (river water, etc.), service water (drinking, etc.) and sewage, environmental behavior of radionuclides, and the various aspects of radiological decontamination.

1. Behavior and Concentrations of Cs-137 and Sr-90 in Fresh Water in Japan

The concentrations of Sr-90 and Cs-137 in river and service water collected by 24 Prefectural Institutes of Public Health, located throughout Japan, were determined monthly during the period 1961 to 1963.

a. Concentrations of Sr-90 and Cs-137 in river water ranged between 0.1 - 1.3 pc/l and 0.0 - 1.0 pc/l, respectively.

b. During the above period, the level of Sr-90 and Cs-137 concentrations originating from fallout showed their highest peaks in May and June of each year, which were the same as the peaks in the seasonal variations of rainfall.

c. The concentrations of Sr-90 and Cs-137 in the water sources decreased in the following order: surface water > submerged ground water > ground water.

d. The average value of the Sr-90 concentration in the service water was 80% of the amount found in the water source. The ratio of Cs-137/Sr-90 in the water source and the service water were 0.52 and 0.27, respectively.

e. The results shown in paras. c and d reveal that the Cs-137 in the source water was effectively removed during the purification process. It was also observed that Cs-137 was easily precipitated on the river bed with sediment, while the Sr-90 moved with the water.

2. The Relation of Radioactivity between Air and Sewage

The estimation of environmental contamination levels and decontamination effectiveness concerning a sewage treatment plant were studied. Our observations on the concentrations of Zr-95-Nb-95, Ru-103, Ru-106-Rh-106, Ce-141 and Ce-144 in rain water and sewage in the Tokyo area indicated that up to thirty per cent of the total radionuclides which fell over the drain area arrived at the sewage treatment plant with the rain water. The total amount, however, depended on the weather conditions during the rain fall. It should be noted that almost all the radioactive substances which entered the sewage treatment plant were adsorbed effectively on the active sludge during the treatment process.

3. Radioactivity Decontamination Materials for Drinking Water

Inhabitants living in remote areas or on the separated islands of Japan depend on rain water for drinking purposes. Therefore, a simple filter to remove radioactivity in rain water is required, especially in cases of nuclear accidents. The capability of removing Sr-90, Cs-137 and I-131 from rain water by ion-exchange resin, vermiculite, calcinated vermiculite, active carbon and various types of charcoal and sea sand were tested.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/850
BRAZIL
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

THE EFFECT OF LIMING ON THE AVAILABILITY OF PHOSPHATE IN "CERRADO" SOILS OF BRAZIL

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The method of isotopic dilution was successfully used to study the influence of limestone in the availability of native phosphorus.

"A" values were determined by a simplified technique using samples of cerrado soils previously submitted in the field to the treatment with different amounts of limestone.

It has been found out:

(1) the three types of cerrado soils had different amounts of available phosphorus;

(2) liming increased linearly the "A" values in the case of two of the soils under study; in the third one, however, the response was linear also up to a point wherefrom a further increase in the amount of limestone applied caused a significant drop in available phosphorus.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/851
BRAZIL
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

The A-value technique as a means of studying phosphate availability in rice soils.

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H. BROESHART*

The present paper describes some experiments carried out in the greenhouse on a number of soil types, using granulated superphosphate labelled with P^{32} as a standard. The effect of time on the specific activities of roots and shoots and the effect of seed phosphorus were studied. Rice plants were used as test plants.

1 - Effect of time - It was found that seed density had little effect on the A-value, even at early stages of development. The specific actividy of roots and shoots was found to be identical for each sampling. It was further established that under submerged conditions the A-value increases with time. When the technique is used to compare A-values of different soils, different phosphate materials or methods of application, it is essential to compare data after the same time of immersion.

2 - Effect of seed phosphorus - Early harvest introduces the effect of seed phosphorus which may constitute an appreciable part of the total phosphorus in the plant. In order to test the effect of seed phosphorus, seed labelled with P^{32} was obtained by applying P^{32} labelled solutions to rice plants at flowering stages. The radioactive seeds were harvested and used for a series of pot experiments.

2.1. - Outgo or exchange of phosphorus from rice plants- Labelled seeds were germinated and subsequently grown on Hoagland nutrient solution. It was found that less than 2% of the total activity of the seeds was found in the remaining culture solutions assayed for P^{32}.

2.2 - Effect of seed density and water conditions on the distribution of seed phosphorus in rice plants - The rice plants were grown under upland and lowland conditions 60-80% of the phosphorus was found back in the shoots. Seed density and water conditions had no effect on the distribution of seed phosphorus.

2.3 - Effect of P level in the soil and source of fertilizer on the distribution of seed phosphorus in rice plants - A sand culture experiment was carried out, comparing the following treatments: 1) two levels of phosphate, 2) two nitrogen sources (NO_3 and NH_4 respectively), 3) three stages of development.

It was found that 60-80% of the seed phosphorus was found back in the shoots. Neither phosphorus level of the culture solutions nor nitrogen source had any effect on the distribution of seed phosphorus.

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Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/852
WMO

February 1964

Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

THE HISTORY OF THE MAJOR PULSES OF TRITIUM IN THE STRATOSPHERE

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In recent years there have been several periods during which substantial amounts of tritium were released at high atmospheric levels, more precisely, in stratospheric regions. Most of this tritium is transformed fairly rapidly into tritiated water, HTO, and will be found, sooner or later, in the various forms of water on our planet. By investigating the abundance of tritium in various natural waters at various times one can assess what can be called the history of these pulses; the history in the sense of a study of where, when and at what concentrations the tritium is appearing. This history, of course, depends strongly on the pattern of the circulation of water in nature. The history of tritium pulses in the sense given above will be a synthesis of all processes which transport the tritium horizontally in the stratosphere and in the troposphere and vertically down to the ground, and of all processes which transport tritium along the earth's surface underground, in lakes and rivers, and, finally, of all processes which transport tritium into the depths of the ocean, the final recluse for this man-made tritium.

Because all processes which are responsible for the transport of tritium in nature can be regarded as quasi-stationary when suitable time-scales are chosen, the history of the tritium pulses contains unique information about these processes. The transports can be expressed in various ways, sometimes they can be specified in terms of vector quantities, sometimes in terms of turnover times and residence times. The amount of information which can be extracted depends simply on how detailed the history of the tritium pulses is known and what auxiliary information is available.

For the study of the history of man-made tritium, observations both in space and time are needed. A beginning has been made on a global scale through the organization of a world-wide network for collection of monthly samples of precipitation and subsequent analyses, a joint IAEA/WMO project in which a number of laboratories take part. A similar network for river waters is needed to follow up the part of the tritium history of fresh waters. Locally, groundwater investigations on tritium are being made. But even if sufficient observation points exist the tritium history has a fourth dimension, time, and observations have to go on for a time period comparable to at least two half-lives of the tritium atom, in order to extract as much information as possible.

From meteorological point of view tritium data on precipitation makes it possible to estimate stratospheric residence times, hemispherical mixing and water vapour transport patterns over continents. In hydrology discussions of continental water balances have been made from tritium data in precipitation and river waters as well as characteristics of smaller catchment areas. The water budget of soil profiles and plants was discussed successfully recently from data on tritium in ground water, soil water, plant water and precipitation. Underground storage of water has been investigated frequently in the past.

For interpretation of tritium data information on the stable isotopes, deuterium or oxygen-18 in water is sometimes most useful.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/853
SOUTH AFRICA
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

RADIOISOTOPE STUDIES OF ADAPTATION TO RESIDENCE AT HIGH ALTITUDES AND TO HEAT STRESS[1]

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Man's adaptation to environment may involve many physiologic processes, among the most important of which are changes in the body's fluid compartments. These changes in fluid compartments are often complex, and lend themselves particularly to study with radioisotopes. The present paper reports the results of such studies of adaptation to two aspects of environmental stress, viz. residence at high altitude, and physical labour under conditions of extreme heat.

While studies of blood volume, total body water and iron metabolism at altitudes above 16 000 ft in the Peruvian Andes have been reported, there is little published data on subjects resident at moderate altitudes at which large numbers of people reside. Studies have therefore been carried out on normal healthy male subjects resident at an altitude of approximately one mile (5 740 ft) above sea level and the results compared to those of subjects resident at sea level. Multiple tracer techniques have been used including measurement of red cell volume with ^{51}Cr, plasma volume with ^{131}I albumin, total body water with $^{3}H_2O$ and total exchangeable sodium with ^{22}Na. Complex changes associated with residence at the higher altitude have been found. The red cell volume is increased and the plasma volume decreased; in this way the total blood volume is not

1/ These studies were supported by a research grant from the Atomic Energy Board, Pretoria.

appreciably changed. The body venous haematocrit ratio is raised. The total body water is similar at altitude and at sea level, but the total exchangeable sodium tends to be lower at the high altitude, and the serum sodium concentration thus reduced.

Physical labour under conditions of heat is necessary in many industries, and study of man's adaptation to such conditions is of practical importance in the prevention of heat exhaustion and heat stroke. Studies have been carried out on normal volunteer subjects who performed physical labour in a heat chamber under conditions of extreme heat and humidity. Multiple radioisotope techniques were used to measure plasma volume, total body water and total exchangeable sodium. Studies included changes accompanying a single exposure to severe heat, as well as those following acclimatization to heat on successive exposures. While changes in plasma volume were not striking, marked changes in total body water and total exchangeable sodium were observed. Of particular interest was the comparatively long period required for re-establishment of equilibrium in the body's fluid compartments following exposure to extreme heat. It is hoped that the results of these studies will enable a rational approach to be made to the problem of acclimatization to work under conditions of extreme heat.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/854
GREECE
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

DETERMINATION OF TRACE ELEMENTS IN THE GREEK LAKES BY NEUTRON ACTIVATION ANALYSIS

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Nuclear reactors are prolific sources of neutrons for producing (n,γ) reactions. Using the Democritus Reactor it has been possible to apply neutron activation analysis for the determination of 14 elements in the waters of the 11 most important lakes of Greece.

The purpose of this study was to determine and compare the stable elements present in microgram and submicrogram quantities in each Lake. Therefore: a) to broaden and extend our knowledge of the abundance of trace elements present in Lakes, b) to find out the geological importance of the elements investigated, c) to extend this study in Lake organisms and have information concerning the biological effect of them.

Samples analyzed were collected from the surface and 5 or 15 meters depth at the deepest point of each Lake throughout Greece. The collection of samples was made from July 16 to August 14, in 1963. The 14 elements investigated were: silver, gold, arsenic, barium, bromine, chlorine, copper, iodine, potassium, manganese, sodium, rhenium, vanadium and zinc.

A quantitative analysis of the above elements present in the samples was accomplished by irradiating a standard with the unknown sample. The comparison of their induced radioactivity was made by gamma scintillation spectrometry. For irradiations up to 30 minutes, the pneumatic facility of our laboratory was used. Such irradiations

were made for silver, vanadium, copper, chlorine, iodine, sodium and manganese. For the rest of the elements, an 8-hour irradiation period was chosen. The neutron flux of the Democritus Reactor was 2×10^{11} neutrons per square centimeter per second.

Non destructive activation analysis was used for silver, chlorine and sodium. The induced activity of silver-110, chlorine-38 and sodium-24 was measured directly on a 3x3 in. thallium activated sodium iodide crystal of a 400 channel analyser.

Rapid radiochemical separations based on solvent extraction techniques were performed for arsenic, copper, gold, rhenium, vanadium and zinc. After irradiation the radioelements produced, together with their respective carriers added were extracted as follows: arsenic as arsenic bromide into benzene from 6.5M sulphuric acid solutions. Vanadium and copper as cupferrates into chloroform from 1.2M hydrochloric acid solutions. Zinc and rhenium as chlorides into 70% n-tributyphosphate in benzene from 4M hydrochloric acid solutions and gold as chloride into ethylacetate from 6M hydrochloric acid solutions. The radioelements together with their carriers were back extracted into the aqueous phase, precipitated with the proper reagents and measured by gamma spectrometry. The whole analysis ranged from 5 min. to 20 min. depending on the element.

For the rest of the elements decontamination steps based on precipitation techniques were performed.

The abundance of the trace elements determined in the Lakes varied according to the element and the Lake. The quantities of chlorine and sodium found ranged from 1.5 up to 130 micrograms per ml of potassium from 0.5 up to 5.0 micrograms per ml. The concentration of the other elements varied from 0.0001 up to 0.500 micrograms per ml.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/855
HUNGARY
February 1964
Submitted in:
ENGLISH and RUSSIAN

Confidential until official release during Conference

Abstract

GAS PHASE METHODS OPERATING AT ATMOSPHERIC PRESSURE FOR THE ANALYSIS OF SOFT β-EMITTING ISOTOPES

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For the measurement of radioactivity of organic compounds labelled with soft β-emitting isotopes /^{3}H, ^{14}C, ^{35}S/ almost exclusively gas counting and/or liquid scintillation methods are employed at present. The most exact analysis can be carried out in proportional region with the aid of an internal gas counter reported by Bernstein and Ballentin. However, filling of such counters requires cumbersome and expensive vacuum systems being.

In our Laboratory an effort has been made to eliminate these difficulties accompanying the traditional analysis of radionuclides of labelled organic compounds by elaborating simple new methods operating exclusively at atmospheric pressure instead of using vacuum lines. This could be achieved by adapting suitably constructed counter systems to the classical combusting methods of organic microchemical analysis. To obtain highly precise results for activity the method of choice must meet the following conditions:

1/ Radionuclides to be analysed must be transformed into simple gaseous compounds possessing favourable properties for proportional counting.

2/ Gases being counted must be chemically indifferent and their radioactive constituents must not show any isotopic exchange under conditions applied.

3/ In order to avoid any loss in activity owing to isotope effects, or cross contamination between samples quantitative processes can be employed for all the chemical transformations.

4/ Activity results must be referred to weighed quantities of original compounds instead fo the volume of gas being measured.

On the basis of these general principles simple, new methods have been developed for the quantitative determination of

a/ tritium in form ethane-^{3}H

b/ radiocarbon in form of carbon dioxide-^{14}C an/or methane-^{14}C

c/ radiosulphur in form of hydrogene sulphide-^{35}S

Accomplishment of analyses requires only some practice in organic microanalysis.

In all of these processes gases to be measured are frozen out in a small, suitably constricted trap built together with the counter. The anode is tungsten wire of o,o3 mm diameter, the cathode is of stainless steel and/or brass in case of the analysis of ^{3}H or ^{14}C but of aluminium in case of the analysis of $H_2{}^{35}S$. The effective volume of the counters is about 5o ml.

In case of the measurement of $^{14}CO_2$ and/or $H_2{}^{35}S$ the filling gas is quantitatively swilled into the sensitive volume of the counter, permitting about 96-98% counting efficiency. However, in case of measurement of methane-^{14}C and/or ethane-^{3}H-ethylene mixture the filling gas is distributed between the sensitive volume of the counter and the volume of the trap. Therefore, these counters are operating with somewhat lower /about 86-88%/ counting efficiency. In all cases excellent characteristic curves could be obtained. The error of reporducibility was found to be less than $\pm$o,5% relative.

Absolute counting rates can also be measured by suitably constructed counters.

The counters can easily be decontamined by flushing out with flowing gas for about 5 minutes. Any increase of background or other "memory effect" have not been observed.

Further details of our counting technique will be discussed.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/856
TURKEY
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

BIOLOGICAL EFFECTS OF TRIATED THYMIDINE IN DROSOPHILA MELANOGASTER LARVAE

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It has been found that the sensitivity of Drosophila Melanogaster larvae exposed to X-rays or fed with tritiated thymidine varies depending on the age of larvae. The elderly larvae are almost not ensitive to small doses of X-rays or low concentrations of tritiated thymidine. On the other hand,it is known that tritiated thymidine is a precursor of DNA and that X-rays have an effect on the synthesis of DNA. In the elderly larvae tritiated thymidine, as well as X-rays, exerts few harmful effects. Therefore, our aim is to find out whether irradiation increases or decreases these effects of tritiated thymidine mentioned above.

We fed tritiated thymidine to three days old larvae and irradiated them with Cobalt 60 of 1.02 curies. We added the triated thymidine to three grams of nutrient and used a dose of 260 roentgens for irradiation.

So far, we have observed that when the larvae in the normal nutrient are irradiated, their life span did not differ from the control ones. Tritiated thymidine and irradiation, when given at the same time to the the larvae, increased their mortality rate. But, tritiated thymidine administered to the larvae, without the accompaniment of irradiation did not cause a comparable high mortality rate. So, tritiated thymidine and X-rays do impose deleterious effects when they are given to the larvae at the same time. If our future experiments confirm the stimulative (cumulative?) effect of these factors, namely tritiated thymidine and irradiation, this fact may be of practical and theoratical use.

We shall continue our experiments by changing the irradiation

dose and concentration of thymidine. In order to study the structural effect of two different doses of irradiation on the incorporation of tritiated thymidine into DNA, we shall prepare samples for autoradiographic investigations from the salivary gland giant chromosomes of the larvae undergoing the above experimentations.

The results of the experiments will be introduced and discussed in detail.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/857
JAPAN
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

SOME ENGINEERING STUDIES CONDUCTED IN INTRODUCING BRITISH TYPE REACTOR FOR THE TOKAI ATOMIC POWER STATION

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In connection with the Tokai Atomic Power Station, The Japan Atomic Power Company and Japan Atomic Energy Research Institute have jointly carried out extensive experimental studies on the engineering and safety aspects of the fuel elements and graphite.

Oxidation of punctured model fuel elements and graphite blocks in atmospheres of either carbon dioxide or air was investigated at various temperatures. Experiments were also undertaken to study the correlation of fission gas release with the extent of carbon dioxide oxidation of irradiated uranium. It was found that the amount of fission gas released during oxidation is roughly proportional to the extent of oxidation. The total amount of fission gas released throughout the oxidation period was, at 500°C, 11% of the initial fission gas content, at 600°C, 25% and at 700°C, 45%. The diffusion coefficients of Xe in the uranium oxides produced by the oxidation were measured as a supplementary experiment. In addition, the effect of carbon dioxide decomposition on the oxidation rate of uranium was also studied.

High temperature creep test were made on uranium in an attempt to study the collapse phenomenon of the fuel element. The secondary

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creep rates of various uranium were measured with a vacuum creep tester under constant loads of 2-3.5 kg/mm^2 at temperatures of 425-575°C. The plots of the creep rates as a function of the logarithm of the loads and of the receprocal of the temperature were found to be linear, and addition of iron or aluminum caused an increase in the creep resistance.

To study the neutron irradiation effect on the mechanical properties of Magnox AL 80, the dependence of the tensile strength on grain size and on deformation rate were investigated exprimentally and the result agreed with Petch's equation.

Since the fuel concerned is a hollow cylinder, collapse of the fuel might occur under reactor condition. To solve this problem, a reduced model of the fuel element was subjected to carbon dioxide pressures of 30-50 kg/cm^2 at temperatures of 450-550°C and thermally cycled between limits of $\pm$20°C. The results showed that the change in diameter were within experimental error and 0.05 mm/month reduction under the loads of less than 30 kg/cm^2 and of 40 kg/cm^2, respectively.

Heat flow characteristics of the fuel element were studied by means of a testing loop operating at 10 kg/cm^2 and at 800°C. A Magnox clad uranium fuel was internally heated in the loop and the heat conduction characteristics and hot spot coefficient were investigated by measuring the temperature distribution of the surface. The extent of deformation and the behavior during pressure reduction were also observed.

Mechanical strength testings were performed on the graphite block by whole piece and the test pieces cut out of the block. Various useful informations were obtained.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/858
Yugoslavia
February 1964
Submitted in:
ENGLISH and RUSSIAN

Confidential until official release during Conference

Abstract

NEUTRON MEASUREMENTS INSIDE REACTORS WITH SEMICONDUCTOR COUNTERS*

by

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In our earlier papers describing the first counting method, the "long-tube" method, which enables simple and direct measurements of high neutron fluxes inside the reactor core, we dealt with its application to relative measurements. By this method, a 6-meter evacuated aluminum tube which is inserted into the reactor core, is used. A target made of fissile materials, Li^6, or B^{10} is placed at the bottom of the tube. At the other end of the tube, outside the core, a semiconductor counter is mounted to detect fission fragments or heavy particles coming from the target due to neutron induced nuclear reactors. Thus, it was shown that high counting rates of neutron reaction products can be achieved with U^{235}, Pu^{239}, Li^6 and B^{10} targets placed inside the reactor core.

To extend this method to absolute measurements of high neutron fluxes, in the present work we have measured parameters defining the observed yield of reactions. With respect to the effect of particle scattering, special care has been taken in choosing the most suitable geometry of the experiment (target-collimator-counter). An additional aluminum tube with a transistor preamplifier and a semiconductor counter at one end is used to vary the distance between the counter and the target.

The yield of the scattered particles was observed with collimators and counters of different diameters. With a collimator 1 cm in diameter, placed 2 m away from the target we obtained a fission spectrum almost identical with the spectrum usually observed with semiconductor counters. This proved that scattering of fragments from the walls of the tube which previously had caused deformation of fission spectra, was eliminated. By this method and with U^{235} target, absolute measurements of thermal neutron fluxes in the Vinča heavy water moderated reactor operating at 6.5 MW were made. The estimated accuracy of the method was about 4%.

* This work was done under Contracts No. RB/179 and RB/130 with IAEA.

Possible applications of this method have also been discussed for neutron flux measurements in advanced reactors with super high neutron fluxes (10^{15} - 10^{16} n/cm^2 sec). This application is based on the fact that the counting rate for the given detector position decreases with time, which is caused by the burn-up of the high cross-section target.

Fast neutron spectra inside the Vinča zero-power heavy water moderated reactor have been measured by using semiconductor counters and a Li^6 target. A new detector-target arrangement has been employed, in which only those products of the Li^6 (n, alpha) T reactions whose mutual angle of emission is different from 180° are detected in coincidence. In this way the thermal neutron interference is completely suppressed. Resolution of the spectrometer as a function of the reactor power and correction factors of the spectometer efficiency for various neutron energies are presented. Direct comparison with the sandwich-target geometry shows some advantages of a new detector-target arrangement for measuring fast neutron spectra inside well-moderated low-power assemblies.